

# Moisture Adsorption as a Function of Relative Humidity

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# Overview

- Moisture Criteria
- Procedure for Moisture Uptake Measurements
- Packaging - Jar Assembly
- Items Exceeding 0.5 wt%
- RH at 0.5 wt% gain
- Time to Failure
- Summary

# Moisture Criteria

DOE Standard 3013, 2000

“Stabilization Acceptance Criterion: The moisture content (weight loss, if using the LOI [Loss on Ignition] method) of Oxide to be packaged in any type of sealed container shall be less than 0.5 wt% at the time of packaging.”

# Procedure for Moisture Uptake

1. Stabilization: 950°C for 2 hr.
2. Pkg in Roland Hagan jar assembly
3. Storage in TA-55 vault (RH 20-22%)
4. Pull samples from containers
  - 50 gram samples TA-55 - lo RH
  - 5 gram samples for CMR - hi RH
5. Weigh sample record RH

# Roland Hagan Jar Assembly



# Moisture Uptake of Pure Items

- Pu >80 wt%:  
<0.14 wt% gain
  - MISNE2
  - 5501579
  - BL-039-11-14-004
  - PPSL-365
- Pu & U >80 wt%  
<0.14 wt% gain
  - SCP711-56AC = MISNE5
  - CAN92
  - 669194
  - PSU-84-06-05
  - \*5501407 (failed because only 1/2 calcined)

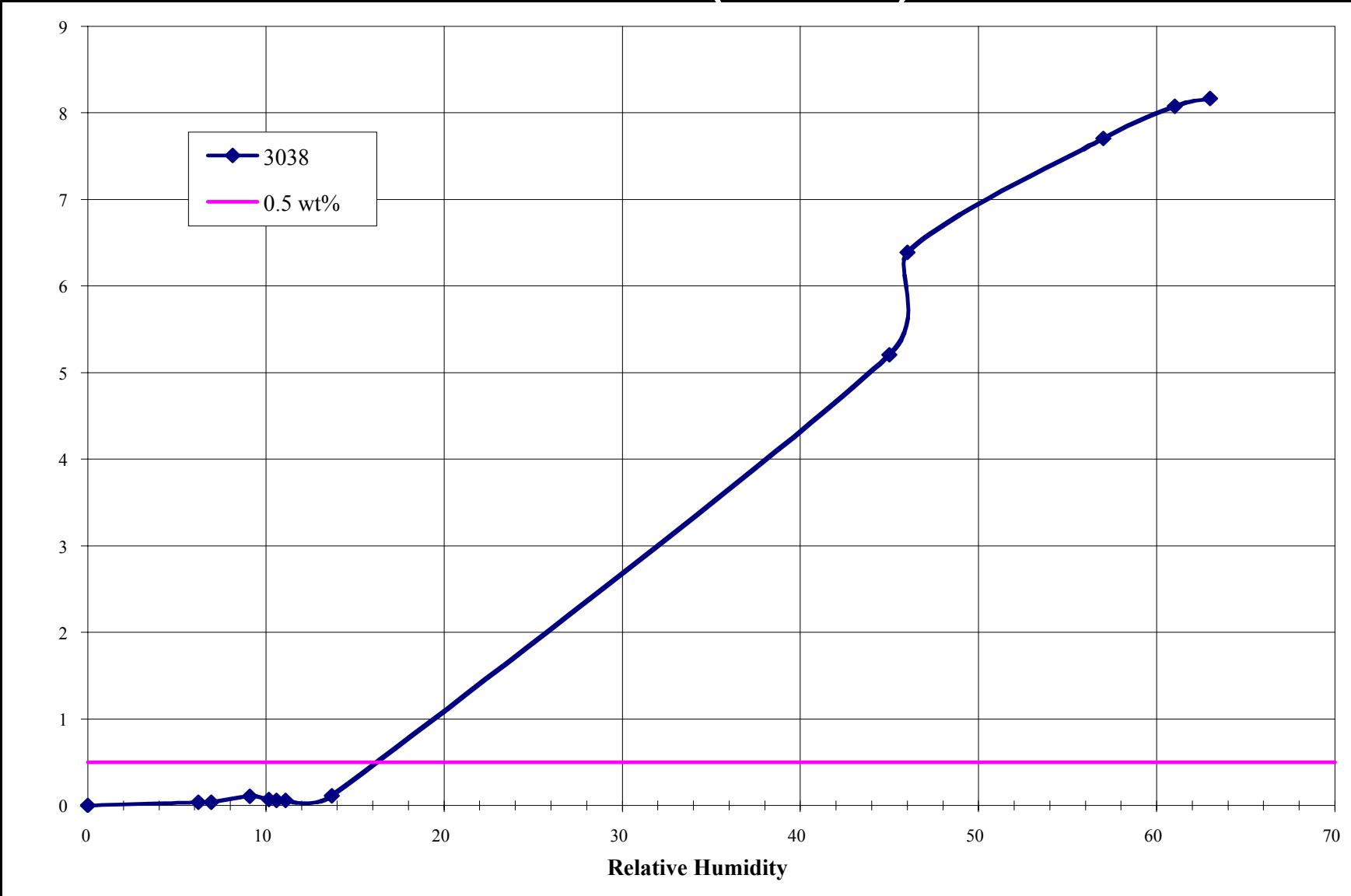
# Impure Items: <80 Wt% PuO<sub>2</sub> & UO<sub>x</sub>

- Gaining  $\leq$  0.2 wt%
  - 07242141A
  - 072422165A
- Gaining 0.46 wt%
  - \*07161856

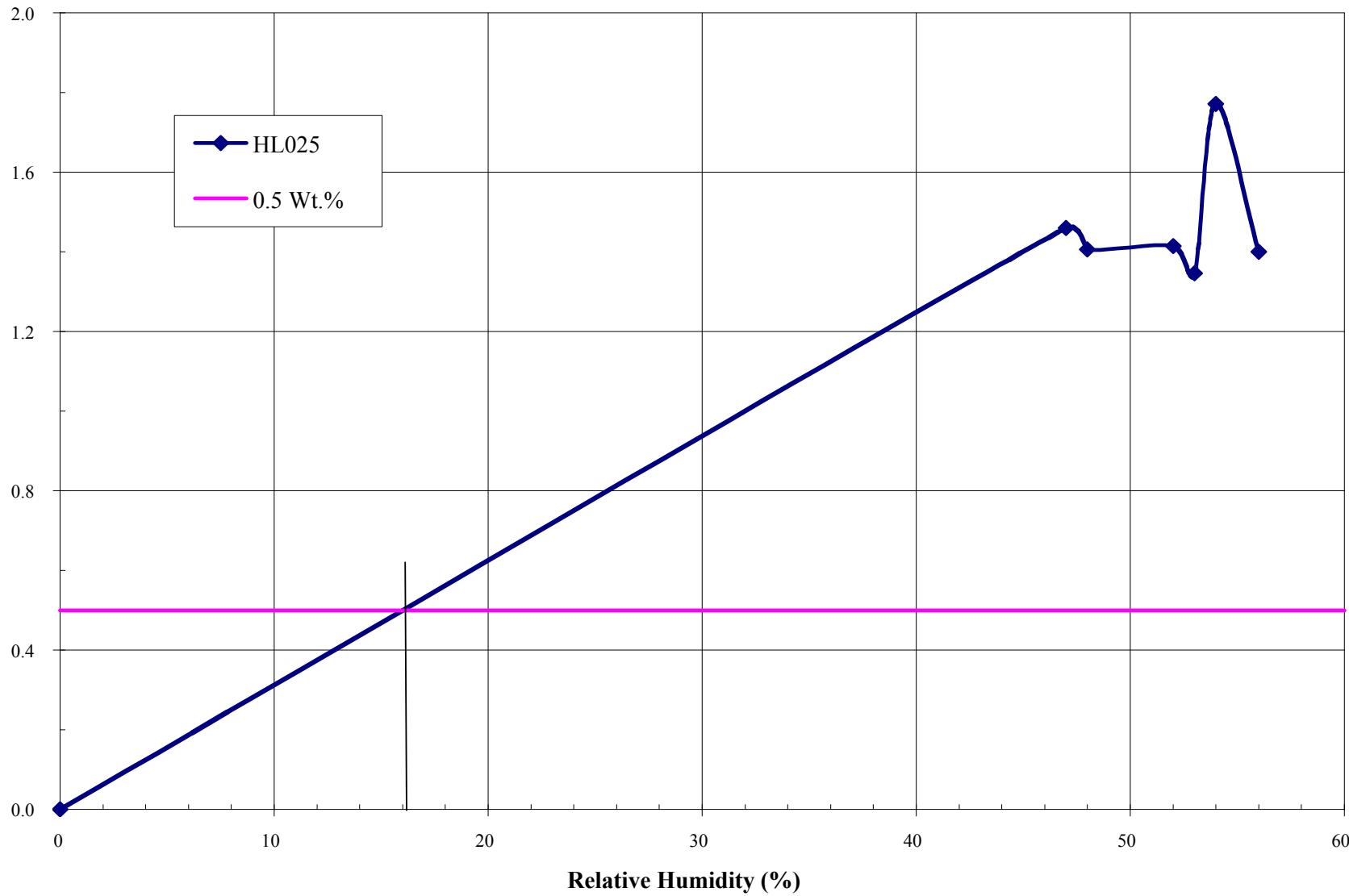
# Impure Items Covered

- Failed 0.5 wt% criteria
  - 053038
  - CLLANL025
  - ARF-102-85-295
  - MISNE4
  - C00024A
- Close to failing;  
data extrapolated
  - ARF-102-85-365
  - 07242201
  - 07161856

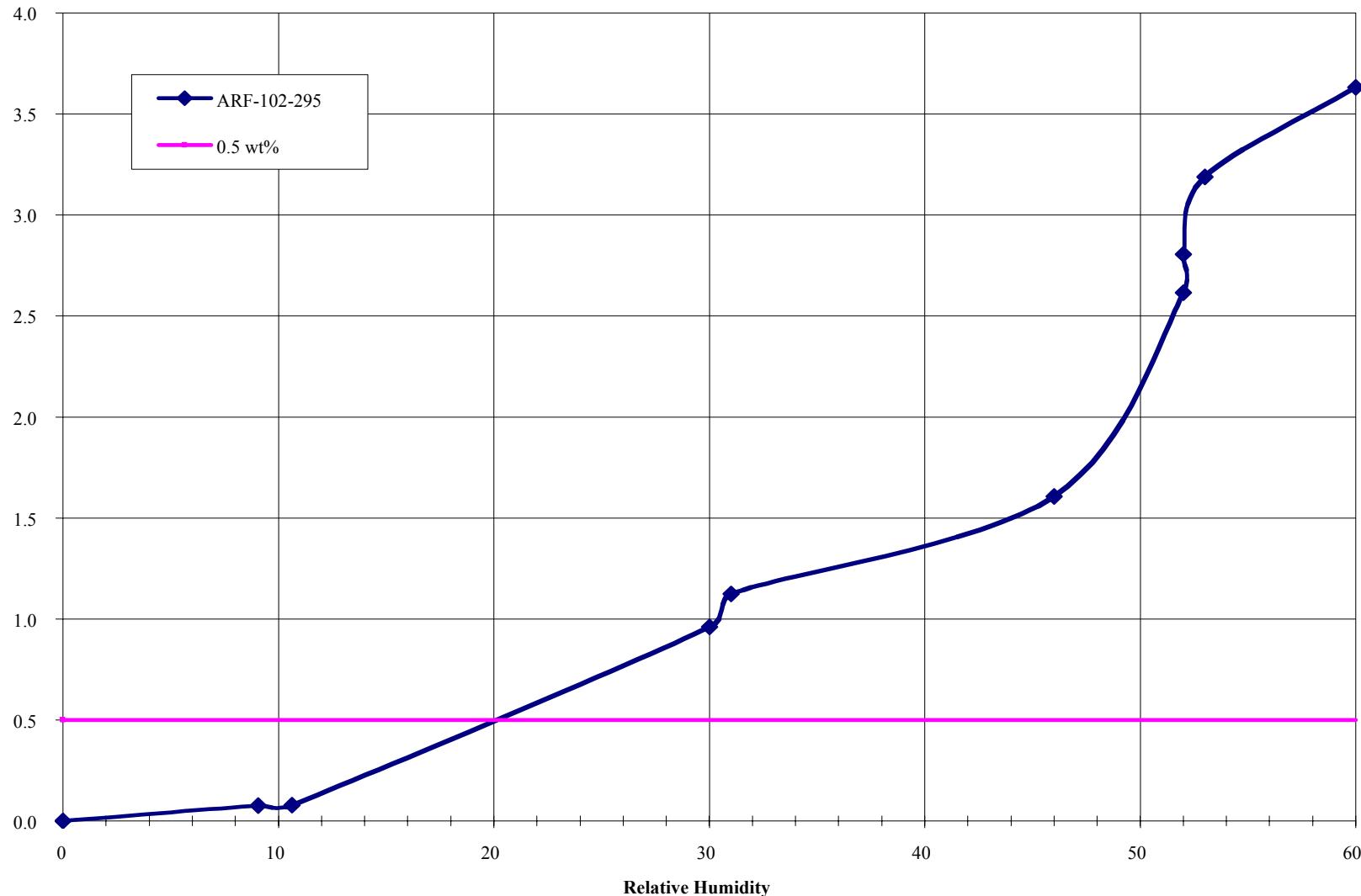
# 053038 (3038)



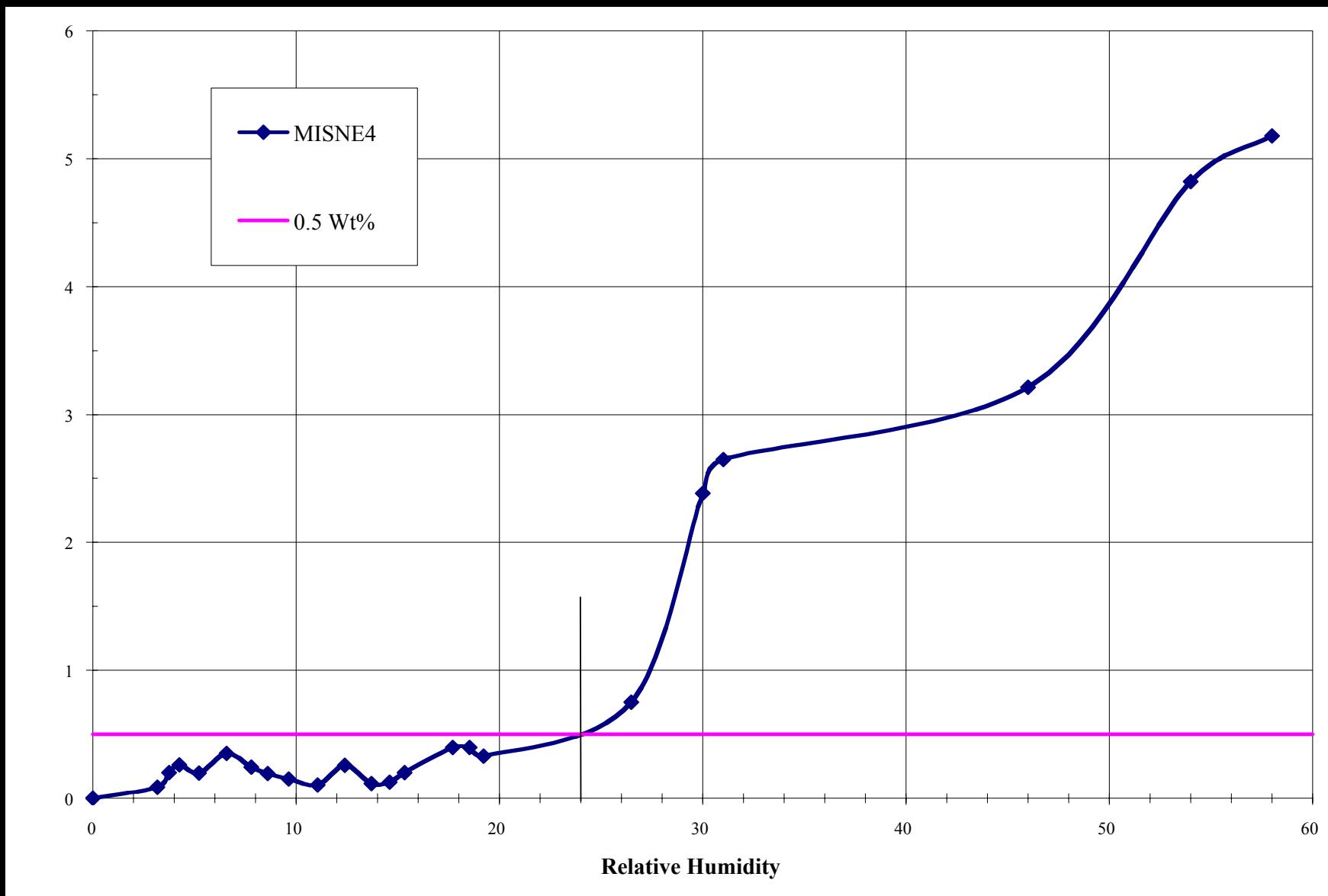
# CLLANL025 (HL025)



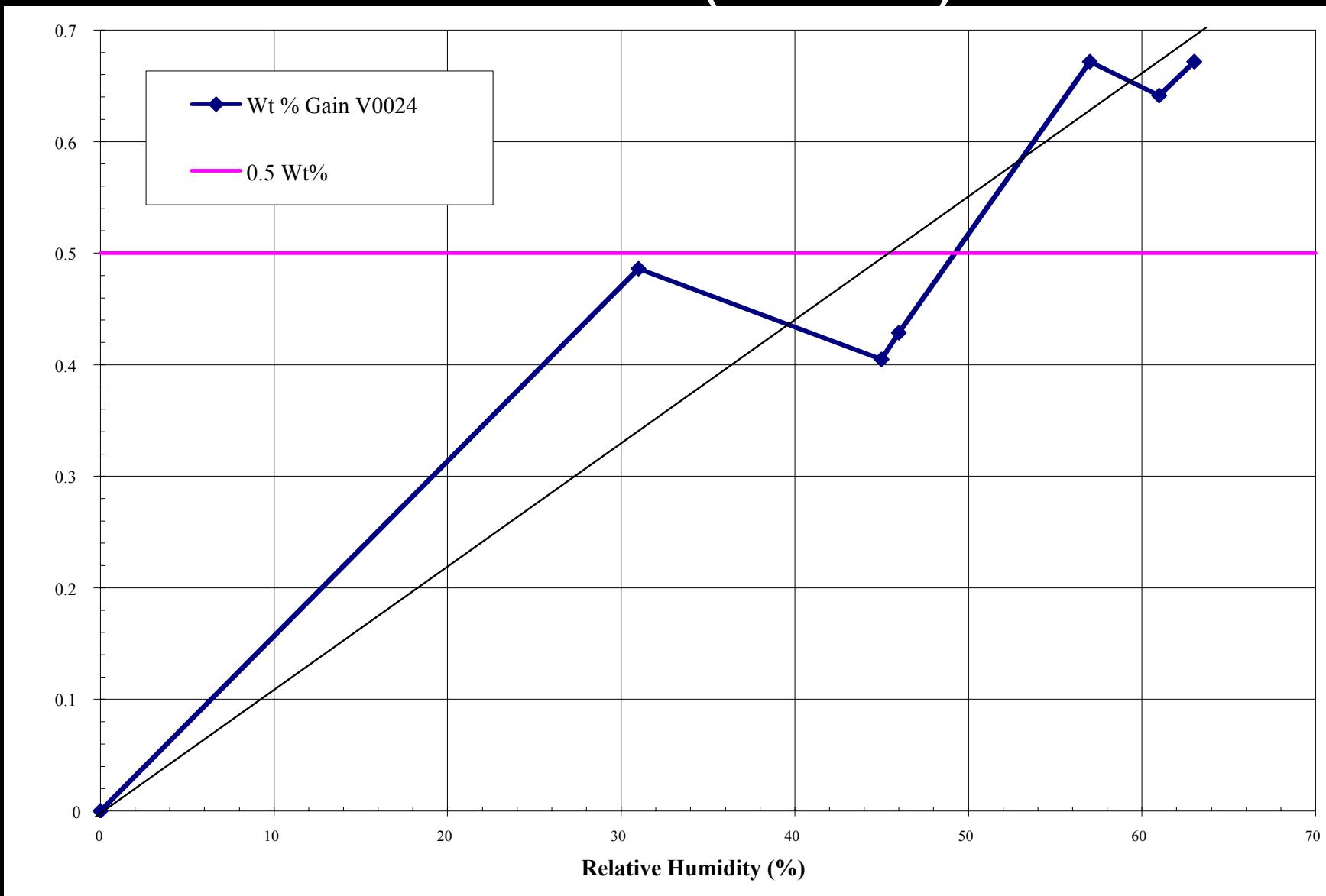
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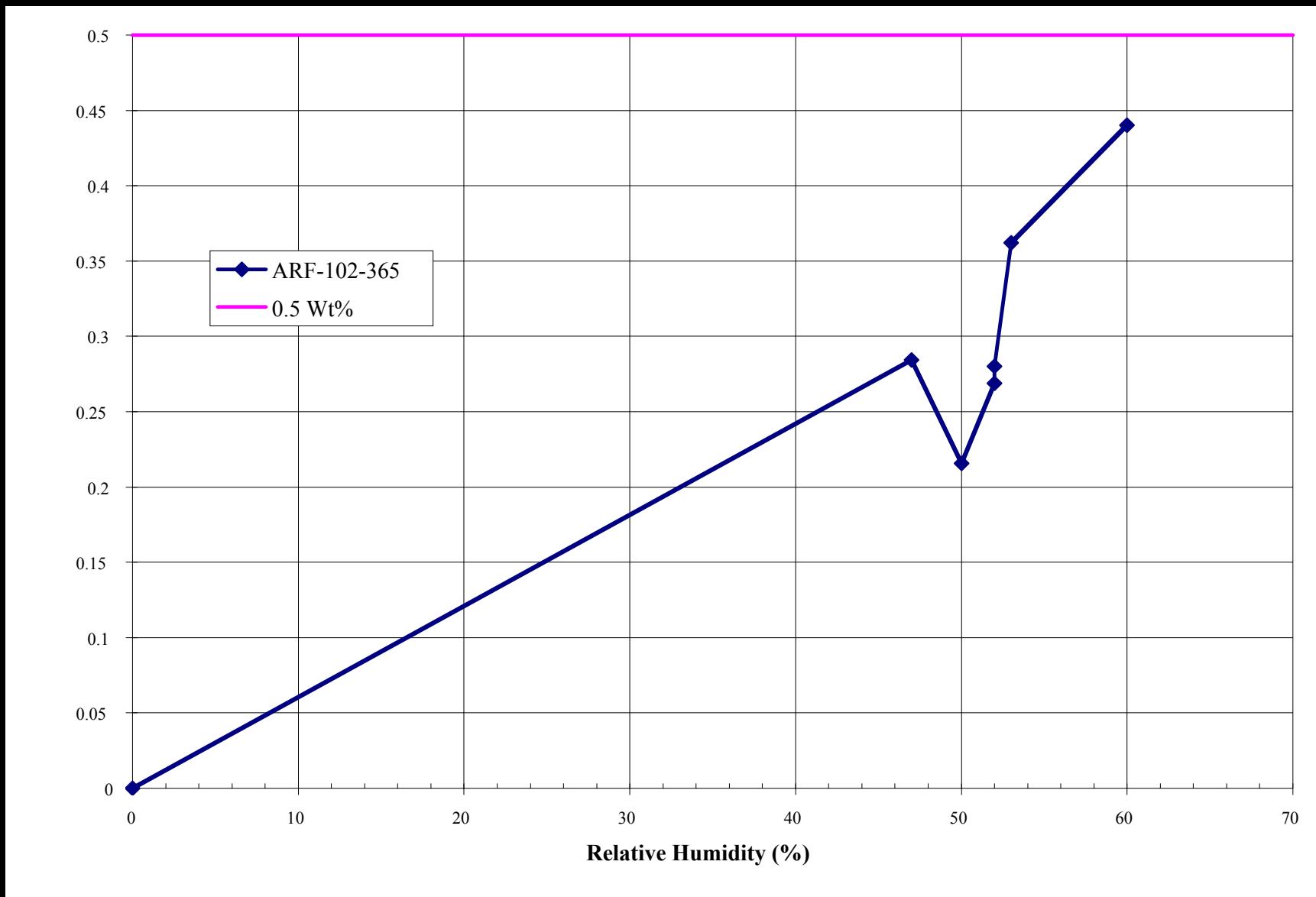
# MISNE4



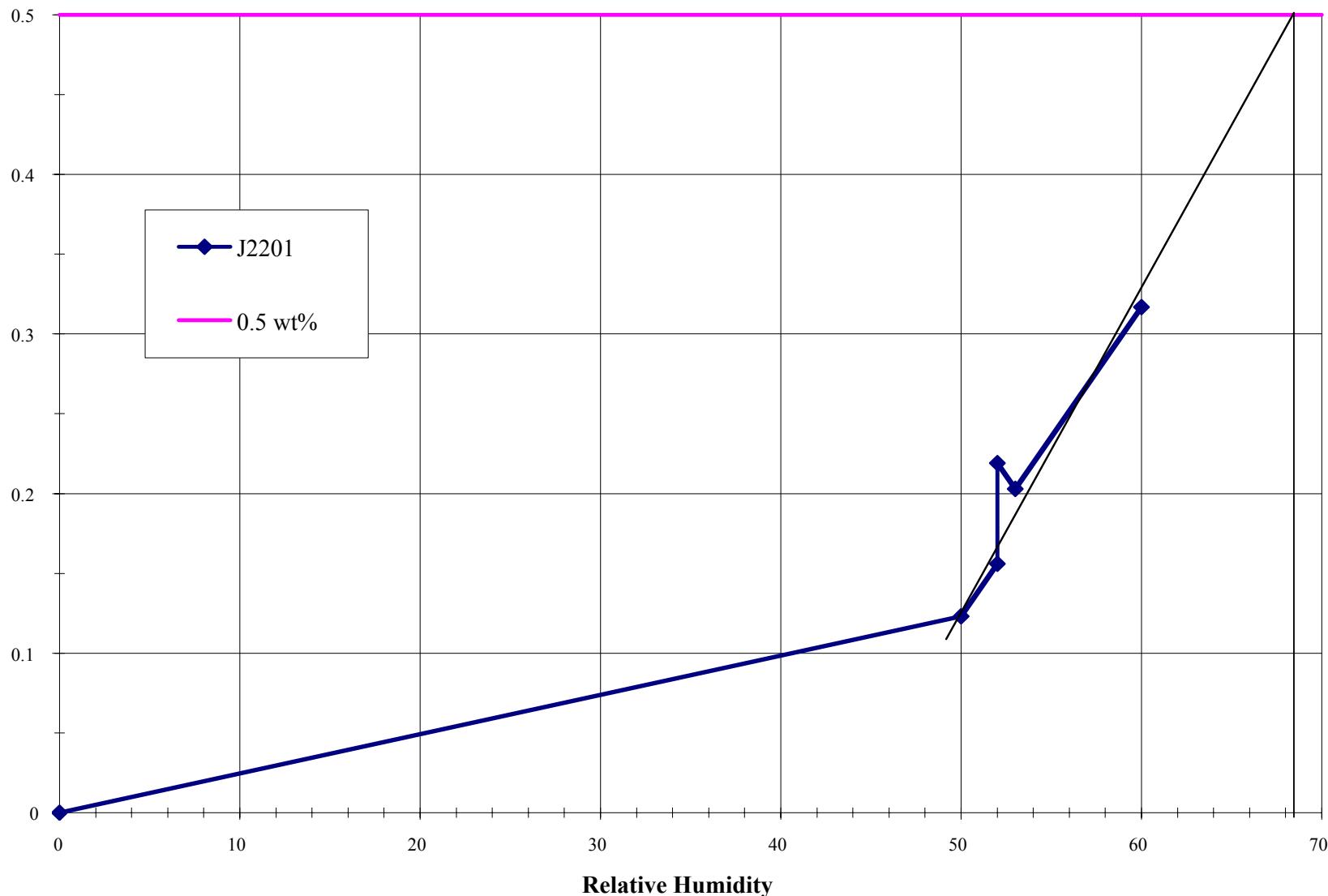
# C00024A (V0024)



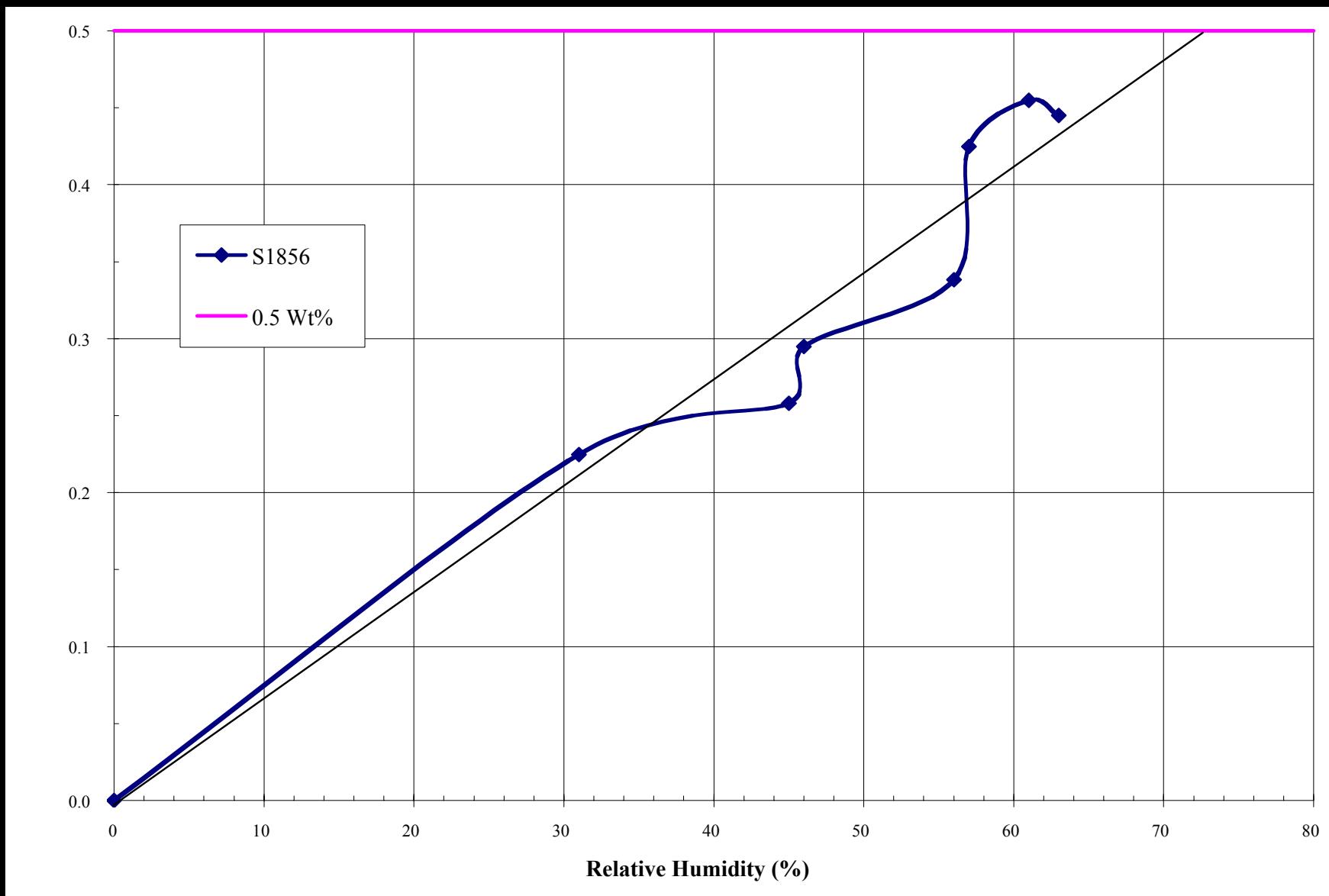
# ARF-102-85-365



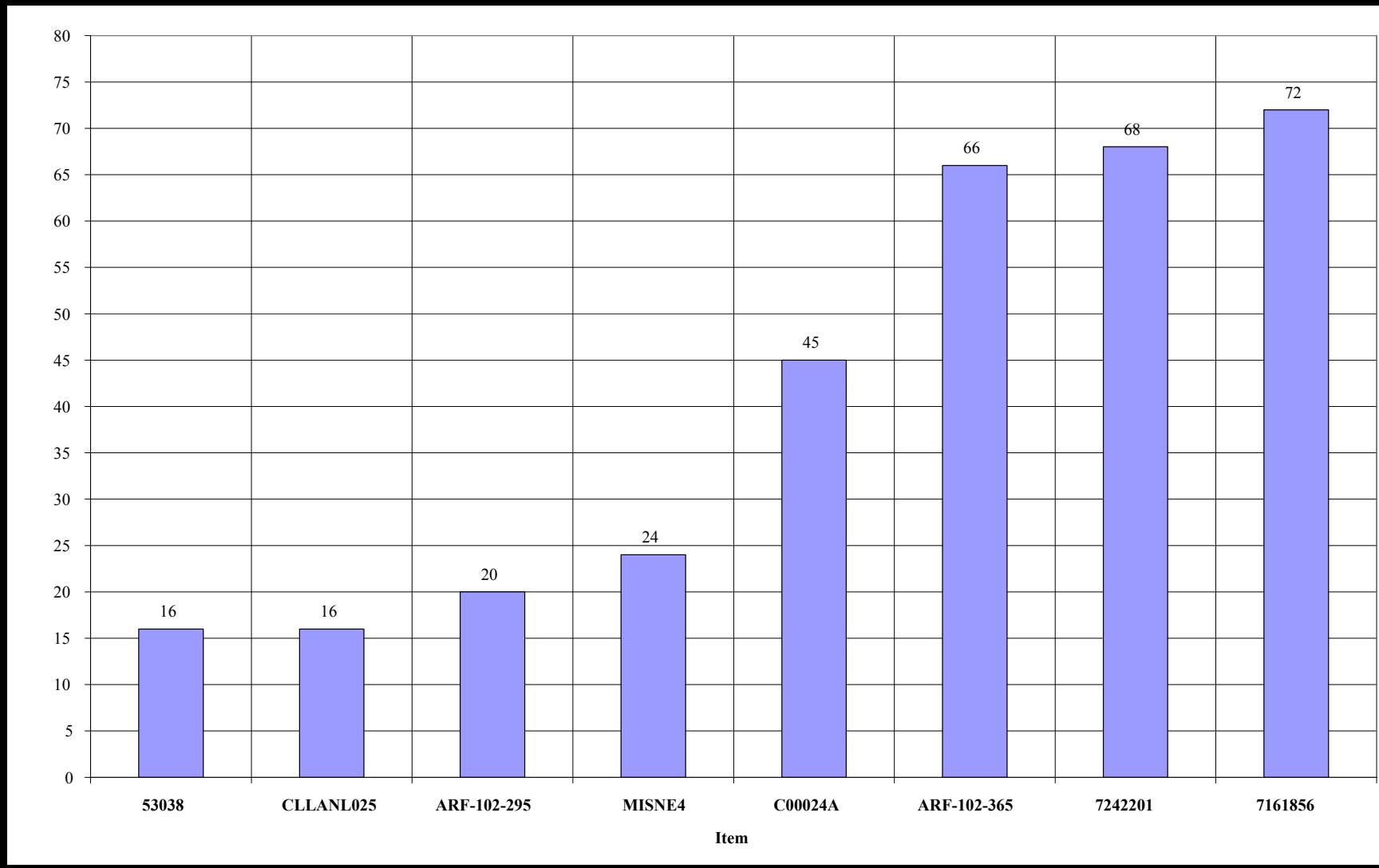
# 07242201 (J2201)

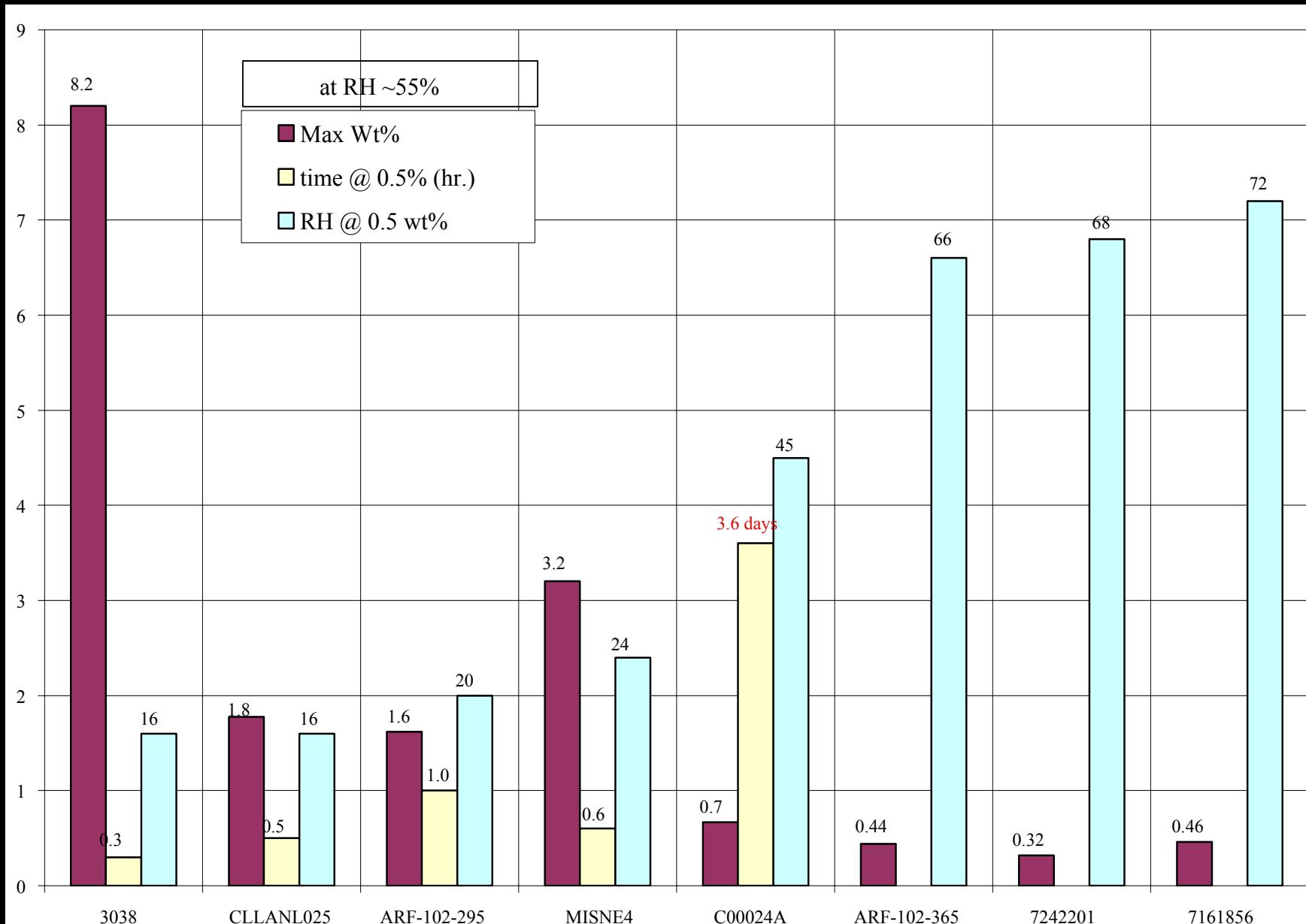


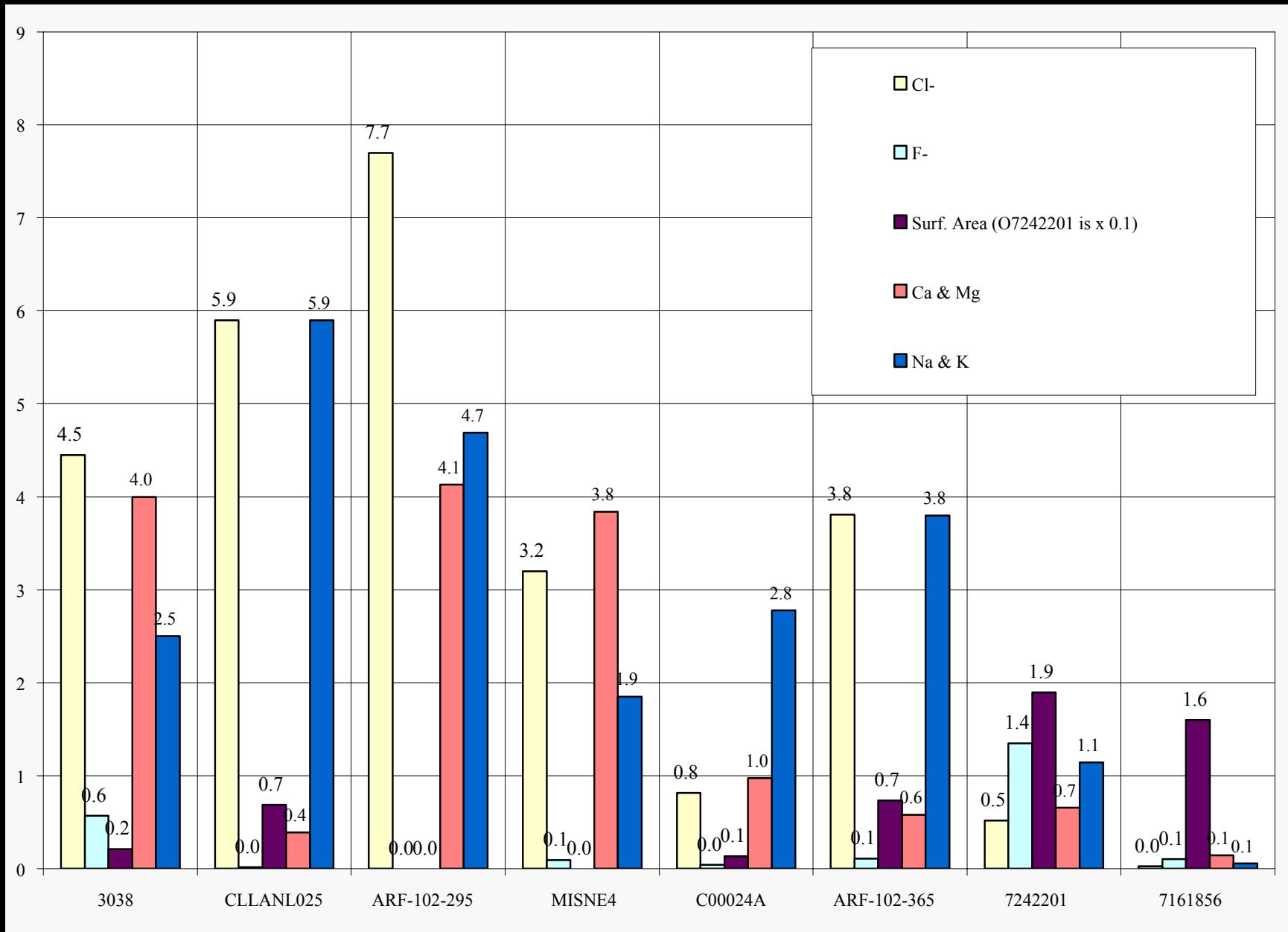
# 07161856

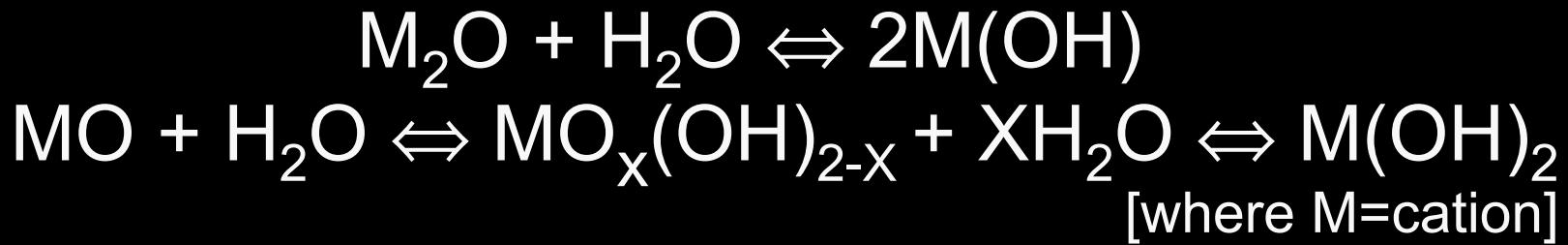


# RH at 0.5 wt% Gain









- $P_{\text{H}_2\text{O}} = e^{-\Delta G/RT}$  ( $\Delta G$  = Gibbs Free Energy)
  - $P_{\text{H}_2\text{O}} = 10^{-7}$  atm for  $\text{Mg(OH)}_2$  forming at Rm Temp.
  - $P_{\text{H}_2\text{O}} = 10^{-1.5-1.9}$  atm = normal RH
- $1 - \alpha = [1 - kt/r_o]^2$  ( $\alpha$  = fraction reacted)
  - 'k' = reaction rate
  - As  $P_{\text{H}_2\text{O}}$  increases the driving potential for the reaction decreases,  $\therefore$  vol. fraction reacted increases

# Moisture Uptake is :

$$[1 - (1 - \alpha)^{1/3}]^2 = (KD/r^2) t \quad (\text{for spherical particles})$$
$$KD/r^2 = \text{Constant}$$

- Initially gas diffusion controlled :  $\alpha \propto (KD/r^2) t$ 
  - Directly  $\propto$  time,  $t$
  - Inversely  $\propto$  to particle size,  $r^2$
  - Controlled by Diffusion Coefficient, D
  - Initial rapid weight gain, settles after  $\sim 1$  day,  $t < 24$  hr.
- Later, controlled by reaction rate at surface: K
  - Kinetic term controlled by the compound forming
  - Rate of formation of product slows down

\*Assuming particle size, temp, and ambient pressure remain constant.

# Conclusions

Through process controls,

time and RH,

items can be packaged to meet 0.5 wt%  
gain criteria in the 3013 Standard.